Claims

What is claimed:

1. A semiconductor device, comprising:

a drain electrode;

a source electrode;

a channel contacting the drain electrode and the source electrode, wherein the channel includes one or more of a metal oxide including zinc-gallium, cadmium-gallium, cadmium-indium;

a gate electrode; and

a gate dielectric positioned between the gate electrode and the channel.

2. The semiconductor device of claim 1, wherein the metal oxide includes an atomic composition of metal (A)-to-metal (B) ratio (A:B), wherein A and B are each in a range of about 0.05 to about 0.95.

3. The semiconductor device of claim 1, wherein the channel includes one of an amorphous form, a single-phase crystalline form, and a mixed-phase crystalline form.

4. The semiconductor device of claim 1, wherein the metal oxide includes one or more of zinc-gallium oxide, cadmium-gallium oxide, cadmium-indium oxide.

5. The semiconductor device of claim 4, where the metal oxide includes an atomic composition of metal(A)-to-metal(B) ratio (A:B), wherein A and B are each in a range of about 0.05 to about 0.95.

6. The semiconductor device of claim 1, wherein the channel includes one or more compounds of the formula $A_xB_xC_xO_x$, wherein each A is selected from the group of Zn, Cd, each B is selected from the group of Ga, In, each C is selected from the group of Zn, Cd, Ga, In, each O is atomic oxygen, each x is independently a non-zero integer, and wherein each of A, B, and C are different.

7. The semiconductor device of claim 6, wherein the one or more compounds of the formula $A_xB_xC_xO_x$ includes an atomic composition of ratio A:B:C, wherein A, B, and C are each in a range of about 0.025 to about 0.95.

8. The semiconductor device of claim 1, wherein the metal oxide includes one or more of zinc-gallium-indium oxide, cadmium-gallium-indium oxide, zinc-cadmium-gallium oxide, zinc-cadmium-indium oxide.

9. The semiconductor device of claim 8, wherein the metal oxide includes an atomic composition of ration A:B:C, wherein A, B, and C are each in a range of about 0.025 to about 0.95.

10. The semiconductor device of claim 6, wherein the one or more compounds of formula $A_xB_xC_xO_x$, includes D_x, to form a compound of the formula $A_xB_xC_xD_xO_x$, wherein D is selected from the group of Zn, Cd, Ga, In, each O is atomic oxygen, each x is independently a non-zero integer, and wherein each of A, B, C, and D are different.

11. The semiconductor device of claim 10, wherein the one or more compounds of the formula $A_xB_xC_xD_xO_x$ includes an atomic composition of ratio A:B:C:D, wherein A, B, C, and D are each in a range of about 0.017 to about 0.95.

12. The semiconductor device of claim 1, wherein the metal oxide includes one or more of including zinc-cadmium-gallium-indium oxide.

13. The semiconductor device of claim 12, wherein the metal oxide includes an atomic composition of ratio A:B:C:D, wherein A, B, C, and D are each in a range of about 0.017 to about 0.95.

14. A semiconductor device, comprising:

a drain electrode;

a source electrode;

means for a channel to electrically couple the drain electrode and the source electrode; and

a gate electrode separated from the channel by a gate dielectric.

15. The semiconductor device of claim 14, wherein the means for a channel includes a means for forming one of an amorphous form, a single-phase crystalline form, and a mixed-phase crystalline form.

16. The semiconductor device of claim 14, wherein the source, drain, and gate electrodes include a substantially transparent material.

17. A method of forming a channel, comprising:

providing at least one precursor composition that includes one or more precursor compounds that include: zinc-gallium oxide, cadmium-gallium oxide, and cadmium-indium oxide; and

depositing the channel including the precursor composition to form a multicomponent oxide from the precursor composition to electrically couple a drain electrode and a source electrode.

18. The method of claim 17, wherein the precursor composition includes a liquid form.

19. The method of claim 18, wherein depositing the channel includes an ink-jet deposition technique when the precursor composition includes the liquid form.

20. The method of claim 17, wherein the precursor composition includes one or more precursor compounds that include A_x, one or more precursor compounds that include B_x, and one or more precursor compounds that include C_x, wherein each A is selected from the group of Zn, Cd, each B is selected from the group Ga, In, each C is selected from the group of Zn, Cd, Ga, In, each x is independently a non-zero integer, and wherein each of A, B, and C are different.

21. The method of claim 20, wherein the one or more precursor compounds includes one or more precursor compounds that include D_x, wherein D is selected from the group of Zn, Cd, Ga, In, each x is independently a non-zero integer, and wherein each of A, B, C, and D are different.

22. The method of claim 17, wherein depositing the channel includes depositing one of an amorphous form, a single-phase crystalline form, and a mixed-phase crystalline form.

23. The method of claim 17, wherein depositing a channel includes step for vaporizing the precursor composition to form a vaporized precursor composition, and depositing the vaporized precursor composition using a physical vapor deposition technique including one or more of dc reactive sputtering, rf sputtering, magnetron sputtering, ion beam sputtering.

24. The method of claim 17, including providing a substrate or substrate assembly; and

forming the semiconductor device on the substrate or substrate assembly.

25. A method of manufacturing a semiconductor device, comprising:

providing a drain electrode;

providing a source electrode;

step for providing at least one precursor composition that includes one or more precursor compounds of zinc oxide, cadmium oxide, gallium oxide, indium oxide, zinc-gallium oxide, cadmium-gallium oxide, and cadmium-indium oxide;

step for depositing a channel including depositing the precursor composition to form a multicomponent oxide from the precursor composition contacting the drain electrode and the source electrode;

providing a gate electrode; and

providing a gate dielectric positioned between the gate electrode and the channel.

26. The method of claim 25, wherein providing the source, the drain, and the gate electrodes includes providing a substantially transparent form of the source, the drain, and the gate electrodes.

27. The method of claim 25, wherein the precursor composition includes one or more precursor compounds that include A_x, one or more precursor compounds that include B_x, and one or more precursor compounds that include C_x, wherein each A is selected from the group of Zn, Cd, each B is selected from the group Ga, In, each C is selected from the group of Zn, Cd, Ga, In, each x is independently a non-zero integer, and wherein each of A, B, and C are different.

28. The method of claim 27, wherein the one or more precursor compounds includes one or more precursor compounds that include D_x, wherein D is selected from the group of Zn, Cd, Ga, In, each x is independently a non-zero integer, and wherein each of A, B, C, and D are different.

29. The method of claim 25, wherein the step for depositing a channel includes an ink-jet deposition technique.

30. The method of claim 25, including providing a substrate or substrate assembly; and

forming the semiconductor device on the substrate or substrate assembly.

31. A semiconductor device formed by steps, comprising:

providing a drain electrode;

providing a source electrode;

providing a precursor composition that includes one or more precursor compounds that include: zinc oxide, cadmium oxide, gallium oxide, indium oxide, zinc-gallium oxide, cadmium-gallium oxide, and cadmium-indium oxide;

depositing a channel including the precursor composition to form a multicomponent oxide from the precursor composition contacting the drain electrode and the source electrode;

providing a gate electrode; and

providing a gate dielectric positioned between the gate electrode and the channel.

32. The semiconductor device of claim 31, wherein the step for depositing a channel includes an ink-jet deposition technique.

33. The semiconductor device of claim 31, wherein the precursor composition includes one or more precursor compounds that include A_x, one or more precursor compounds that include B_x, one or more precursor compounds that include C_x, wherein each A is selected from the group of Zn, Cd, each B is selected from the group Ga, In, each C is selected from the group of Zn, Cd, Ga, In, each x is independently a non-zero integer, and wherein each of A, B, and C are different.

34. The semiconductor device of claim 33, wherein the one or more precursor compounds includes one or more precursor compounds that include D_x, wherein D is selected from the group of Zn, Cd, Ga, In, each x is independently a non-zero integer, and wherein each of A, B, C, and D are different.

35. The semiconductor device of claim 34, wherein depositing the channel includes vaporizing the precursor composition to form a vaporized precursor composition, and depositing the vaporized precursor composition using a physical vapor deposition technique including one or more of dc reactive sputtering, rf sputtering, magnetron sputtering, ion beam sputtering.

36. A method for operating a semiconductor device, comprising:

providing a semiconductor device that includes a source electrode, a drain electrode, and a channel to electrically couple the source electrode and the drain electrode, a gate electrode separated from the channel by a gate dielectric, wherein the channel includes a multicomponent oxide including at least one metal cation from group 12, and at least one metal cation from group 13, wherein group 12 cations includes Zn and Cd, and group 13 cations includes Ga and In, to form at least one of a three-component oxide, a four-component oxide,

and a two-component oxide that includes zinc-gallium oxide, cadmium-gallium oxide, cadmium-indium oxide; and

applying a voltage to the gate electrode to effect a flow of electrons through the channel.

37. The method of claim 36, wherein operating the semiconductor device includes using the semiconductor device as a switch in a display device.

38. The method of claim 36, wherein operating the semiconductor device includes conducting electrons through the channel in a linear region of operation.

39. A display device, comprising:

a plurality of pixel devices configured to operate collectively to display images, where each of the pixel devices includes a semiconductor device configured to control light emitted by the pixel device, the semiconductor device including:

a drain electrode;

a source electrode;

a channel contacting the drain electrode and the source electrode, wherein the channel includes one or more of a metal oxide including zinc-gallium, cadmium-gallium, cadmium-indium;

a gate electrode; and

a gate dielectric positioned between the gate electrode and the channel and configured to permit application of an electric field to the channel.

40. The display of claim 39, wherein the source, the drain, and the gate electrodes include a substantially transparent material.

41. The display of claim 39, wherein the metal oxide includes an atomic composition of metal(A)-to-metal(B) ratio (A:B), wherein A and B are each in a range of about 0.05 to about 0.95.

42. The display of claim 36, wherein the channel includes one or more compounds of the formula $A_xB_xC_xO_x$, wherein each A is selected from the group of Zn, Cd, each B is selected from the group of Ga, In, each C is selected from the group of Zn, Cd, Ga, In, each O is atomic oxygen, each x is independently a non-zero integer, and wherein each of A, B, and C are different.

43. The display of claim 42, wherein the one or more compounds of the formula $A_xB_xC_xO_x$ includes a ratio of A:B:C, wherein A, B, and C, are each in a range of about 0.025 to about 0.95.

44. The display of claim 42, wherein the one or more compounds of formula $A_xB_xC_xO_x$, includes D_x, to form a compound of the formula $A_xB_xC_xD_xO_x$, wherein D is selected from the group of Zn, Cd, Ga, In, each O is atomic oxygen, each x is independently a non-zero integer, and wherein each of A, B, C, and D are different.

45. The display of claim 44, wherein the one or more compounds of the formula $A_xB_xC_xD_xO_x$ includes a ratio of A:B:C:D, wherein A, B, C, and D, are each in a range of about 0.017 to about 0.95.

46. The display of claim 36, wherein the one or more compounds include one of an amorphous form, a single-phase crystalline form, and a mixed-phase crystalline form.